User manual v2.0.0

PhaseView

GetLase: User manual v2.0.0

PhaseView

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Chapter 1. Introduction

GetLase is an advanced software dedicated to laser beam measurement. It allows complete control of BeamWave wavefront measurement system, as well as detailed measurement analysis.

1.1. Software installation

GetLase software consists of the following components:

- Installation CD
- HASP protection key

To install GetLase on your system, run setup.exe from the installation CD and follow the installation procedure. All necessary components will be installed automatically.

When the software installation is complete, you can connect the HASP key and the measurement system to your computer.

Warning

Do not connect the acquisition system to your computer before GetLase is fully installed.

Minimum configuration	
OS	Windows XP, Vista, 7
CPU speed	1GHz
RAM	2 Gb
Connexions	2 USB 2.0 port
Graphics card	128 Mb memory

Table 1.1. System requirements

1.2. Hardware installation

The acquisition system is composed of the following elements:

- BeamWave sensor head with C-Mount protection cap
- USB cable

Figure 1.1. BeamWave sensor

Set in place the BeamWave sensor as follows:

1. Put the camera on a mount integrated in the existing optical setup
2. Attach the camera on the mount using some of the 4 M6-threaded holes in BeamWave base plate (maximum length 6mm) or the C-Mount present on the front face of the camera (1"-32 thread, maximum length 4mm)
3. Attach the camera holder in the optical setup, in order for the measured laser beam to enter the window in front of the BeamWave
4. Connect the camera to a USB 2.0 port on your computer, using the USB 2.0 cable
5. Window's New Hardware Wizard will pop-up detecting a new "Lumenera Unconfigured Device". Select Install the software automatically from the options that are presented to you and click Next. A warning may appear notifying you that the drivers have not been digitally signed by Microsoft. Click Continue Anyway to continue with the driver installation. Then click Finish to complete the installation of the drivers.

You are now ready to start a measurement. You can start GetLase.exe.

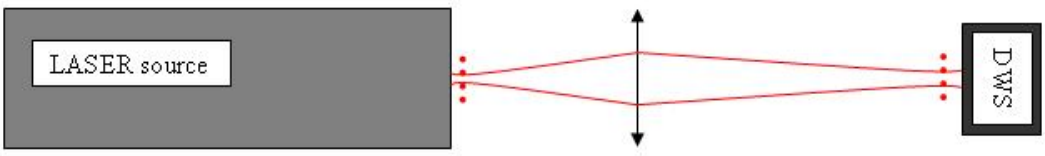

Figure 1.2. Typical measurement setup

The laser source illuminates a lens and BeamWave is used to measure the new waist (dots) and beam.

1.3. Software description

Main software panel consists of 2 parts.

On the left part, you will find:

- The sensor control panel, for controlling sensor settings and data acquisition.
- The properties tabs, for reviewing and modifying software properties.

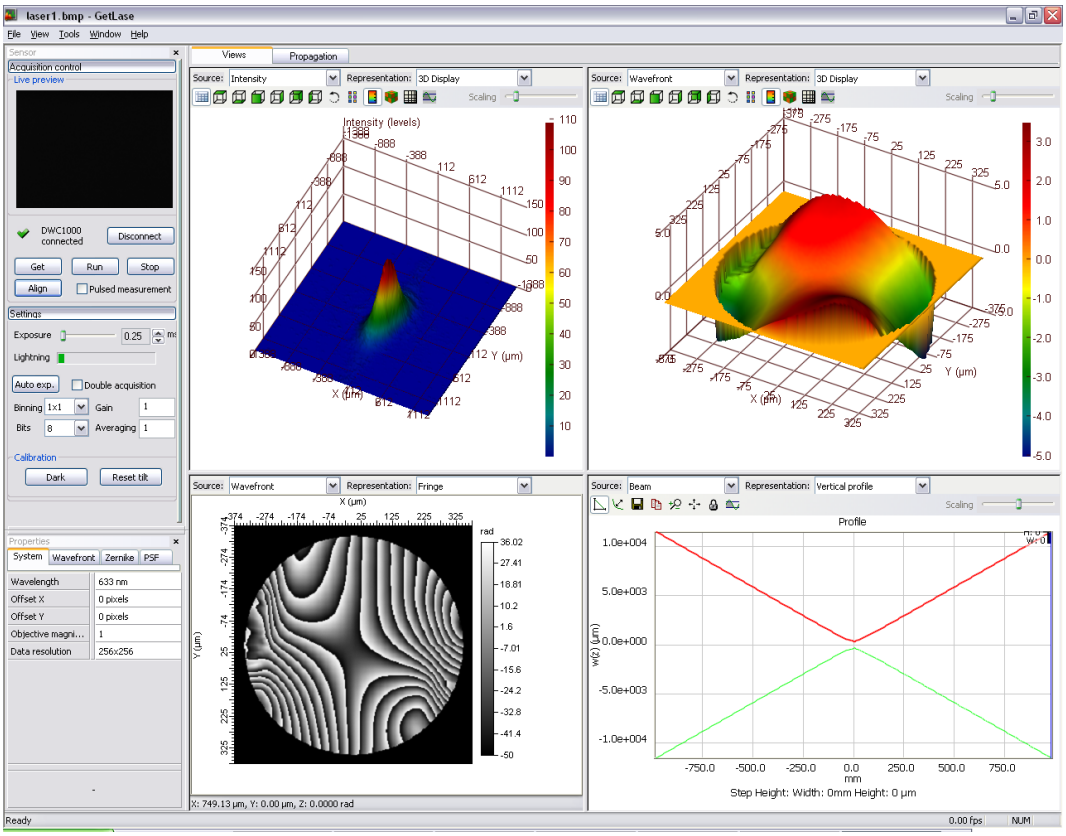

Figure 1.3. Main screen

The right part of the screen is divided into 1, 2 or 4 sub-windows for visualizing measurement results. You can easily modify the size and content of each sub-window to adapt the display to your needs. To change the number of sub-windows, use the WINDOWS menu or drag the bar separating the windows to the edge of the screen.

The right part can only display the propagation tab. This tab is only available after data has been acquired or loaded.

Chapter 2. Data acquisition

The complete measurement procedure will be described step-by-step in this section.

2.1. Connect to measurement system

Attach the system to your computer via the USB cable. Then press CONNECT.

In case of connection problem, verify that the USB cable is connected at both ends, then try again.

2.2. Set-up camera

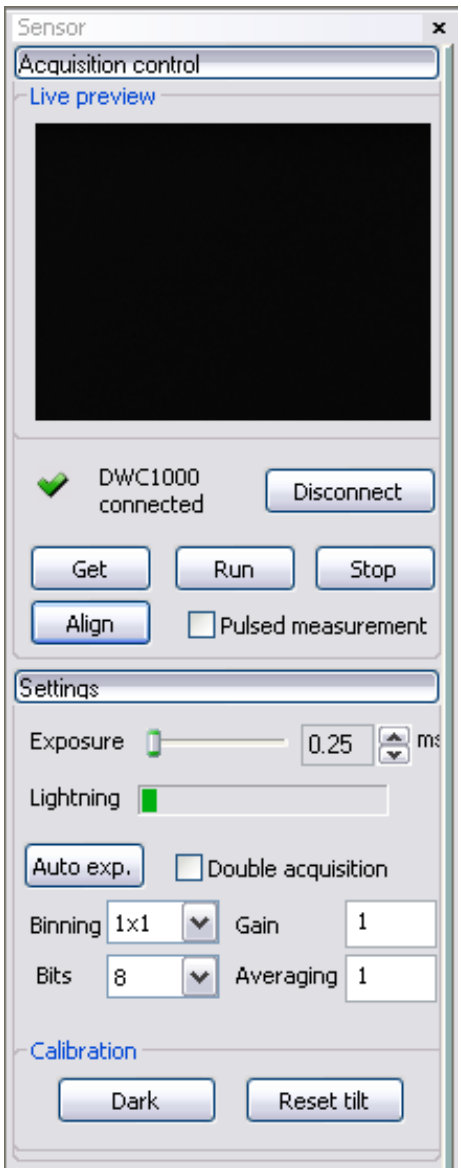

Figure 2.1. Camera panel

Camera set-up is straightforward. Simply follow the procedure below:

1. Turn on the light source and align the sensor so that the sample image falls on the sensor. The beam is aligned when both spots are approximately centered in their respective half-images.

2. Press AUTOEXPOSURE to adjust *camera exposure time* automatically

3. Block the light source using a beam blocker and press the DARK button to *measure dark signal*

4. Your are now ready to measure. If necessary, the other sensor parameters can be adjusted. Refer to the table below for a description fo the different parameters.

Parameter	**Description**
Binning	Binning improves signal to noise ratio and increases measurement speed by combining several pixels together. However it reduces lateral resolution.
Gain	It is recommended to set gain to 1.5. Gain can be increased when signal is too weak.
Bits	It is recommended to use 16 bits mode.
Averaging	Averaging improves measurement signal to noise ratio but combining several images together. However it reduces acquisition speed.
Double acquisition	Double acquisition should be turned ON for samples with highly non-uniform intensity.

Table 2.1. Camera parameters

Pulsed measurement mode is for pulsed lasers with slow repetition rate: the camera waits until a pulse is detected to trigger a measurement.

2.3. Alignment mode

For optimum sample alignment, you can use the alignment mode by pressing the ALIGN button.

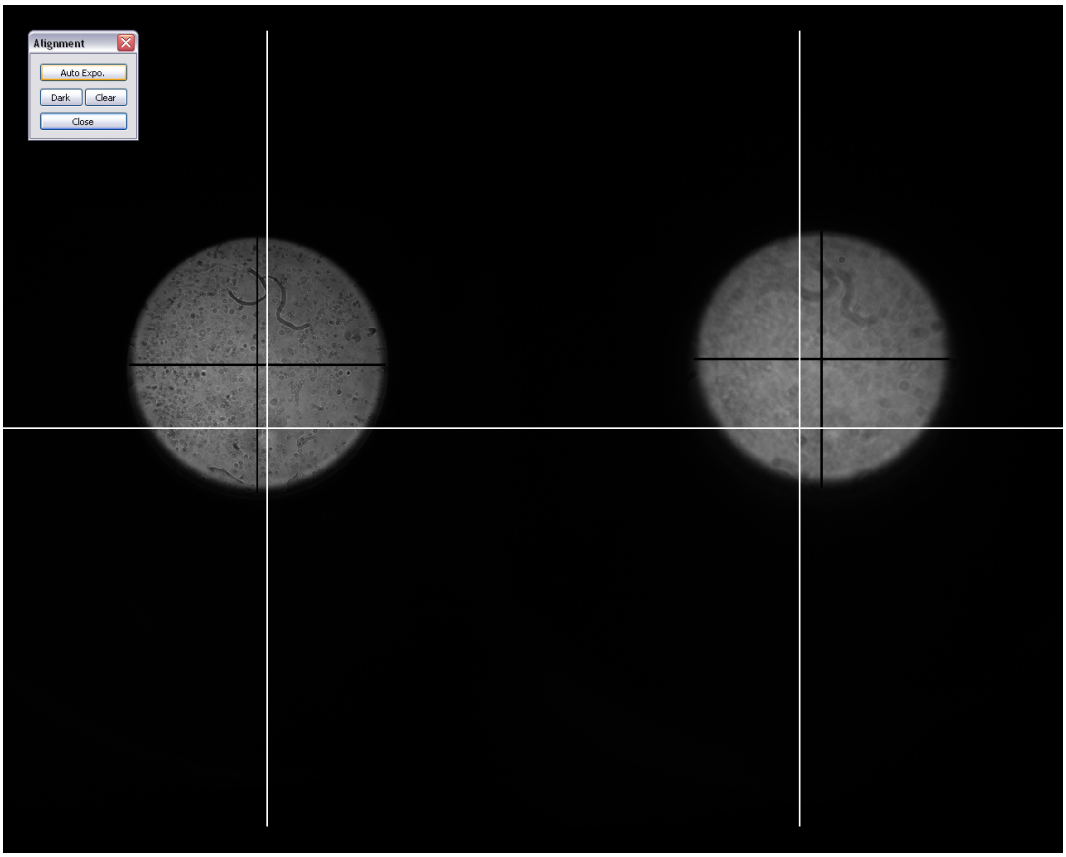

Figure 2.2. Alignment window

The alignment mode window shows the sensor live image. The spot centers are marked as black crosses. The sample is perfectly aligned when the black crosses overlap with the white crosses.

Note

Perfect alignment is *not* required for measurement.

2.4. Measurement parameters

Before starting a measurement, enter the following system parameters:

- Wavelength: Central wavelength of the light source, in nm
- Objective magnification: Magnification of the objective that is attached to BeamWave sensor

2.5. Tilt measurement

Tilt measurement is always relative to some reference direction. By default, the default direction is the direction perpendicular to the sensor plane.

It is usually useful to measure tilt with respect to some reference beam. This can be done easily in GetLase software, as follows:

1. Illuminate the sensor with the reference beam.
2. Press RESET TILT button. The reference direction will be set to the direction of the reference beam. Tilt values will be measured with respect to the reference direction.

If you are not interested in tilt measurement, you can disable it from the WAVEFRONT PREFERENCE menu

2.6. Reference data

It is often useful to perform wavefront measurements with respect to some reference. In that case the system compares the wavefront of the current sample to some reference wavefront.

This can be done easily in GetLase, by specifying a measurement file to use as a reference. This is done in PROPERTIES > WAVEFRONT.

When REMOVE REFERENCE is selected, the reference data is subtracted from each measurement.

2.7. Start measurement

There are 2 available measurement modes:

- *Single-shot measurement*: Press GET to perform one wavefront measurement.
- *Continuous measurement*: Press RUN to start continuous measurement. Measurement data will update continuously. Repetition rate depends on camera integration time and computer speed. To stop the measurement, press the STOP button.

Chapter 3. Data analysis

This chapter presents the different available views. Each view can be adjusted to your needs, by choosing a *content* and *representation*.

Available contents are:

- Intensity data
- Beam data
- Wavefront data (optional)
- Zernike data (optional)
- PSF data (optional)

Available representations are:

- 3D display
- 2D display
- Horizontal profile
- Vertical profile
- Histogram
- Properties
- Fringe

Each content is described in detail in the following sections.

3.1. Intensity data

This view represents the beam intensity distribution in the pupil plane, in arbitrary units (camera levels).

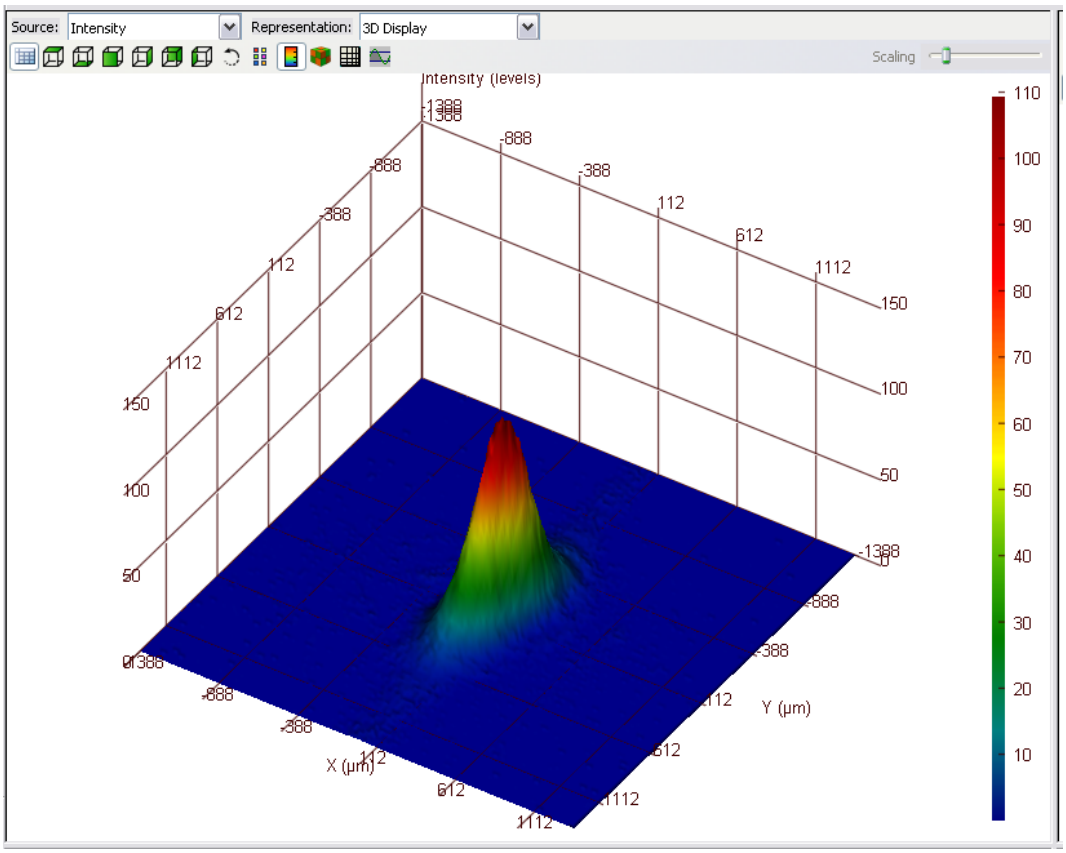

Figure 3.1. Intensity view

The property view for intensity data gives additional information:

Parameter	Units	Comments
Imax	levels	Maximum intensity levels in the acquired image.
x0	mm	Beam position along X axis from the center of the sensor.
y0	mm	Beam position along Y axis from the center of the sensor.
Waist major	µm	Beam major axis diameter in the acquisition plane.
waist minor	µm	Beam minor axis diameter in the acquisition plane.
Ellipticity	None	Ellipticity of the beam spot: the closer it is to 1, the closer the beam spot is to a circular one.
Orientation	degrees	Orientation of the ellipse major axis with respect to X-axis.

Table 3.1. Intensity properties

3.2. Beam data

This view represents the beam width along X and Y as a function of Z.

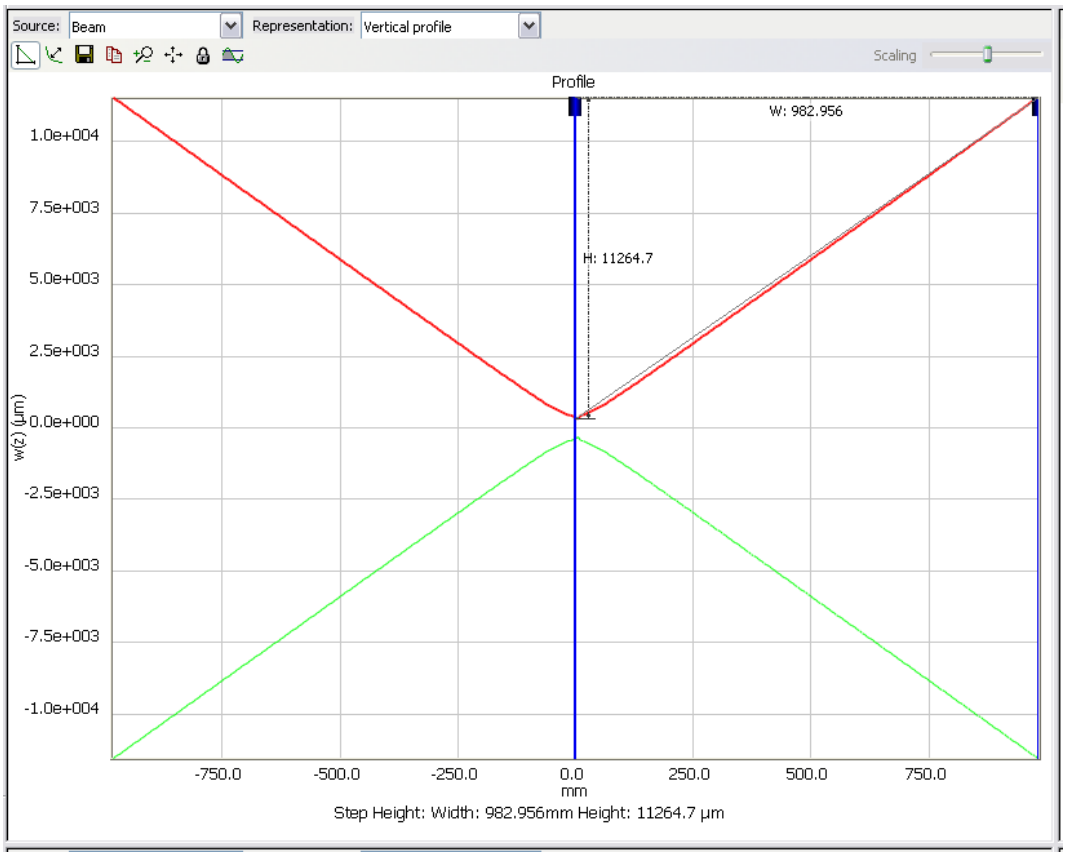

Figure 3.2. Beam view

The property view for beam data gives additional information:

Parameter	Units	Comments
M²	None	M² parameter for the X and Y directions. A M² of 1 is obtained for a TEM00 beam. More divergent beams will produce a larger M².
2*W0	µm	Waist diameter in X and Y directions. This is the smallest dimension the beam can reach in its current propagation state.
z-z0	mm	Distance from the beam waist to the sensor. If negative, the waist is located after the sensor.
zR	mm	Rayleigh range of the beam.
theta	mrad	Divergence angle of the beam, which gives the divergence ratio of the beam far from the waist location.
R	mm	Radius of curvature of the wavefront in the measurement plane.
Waist astigmatism	None	Represents the relative difference in waist locations in X and Y.
Waist asymmetry	None	Represents the ratio of waist diameters in X and Y.
Divergence asymmetry	None	Represents the ratio of beam divergences in X and Y.

Table 3.2. Beam properties

3.3. Wavefront data

This view represents the beam wavefront in the pupil plane, in µm. You can adjust how wavefront is represented in PROPERTIES > WAVEFRONT:

- Check REMOVE TILT X to ignore tilt component along X in the wavefront representation
- Check REMOVE TILT Y to ignore tilt component along Y in the wavefront representation
- Check REMOVE DEFOCUS to ignore defocus component in the wavefront representation

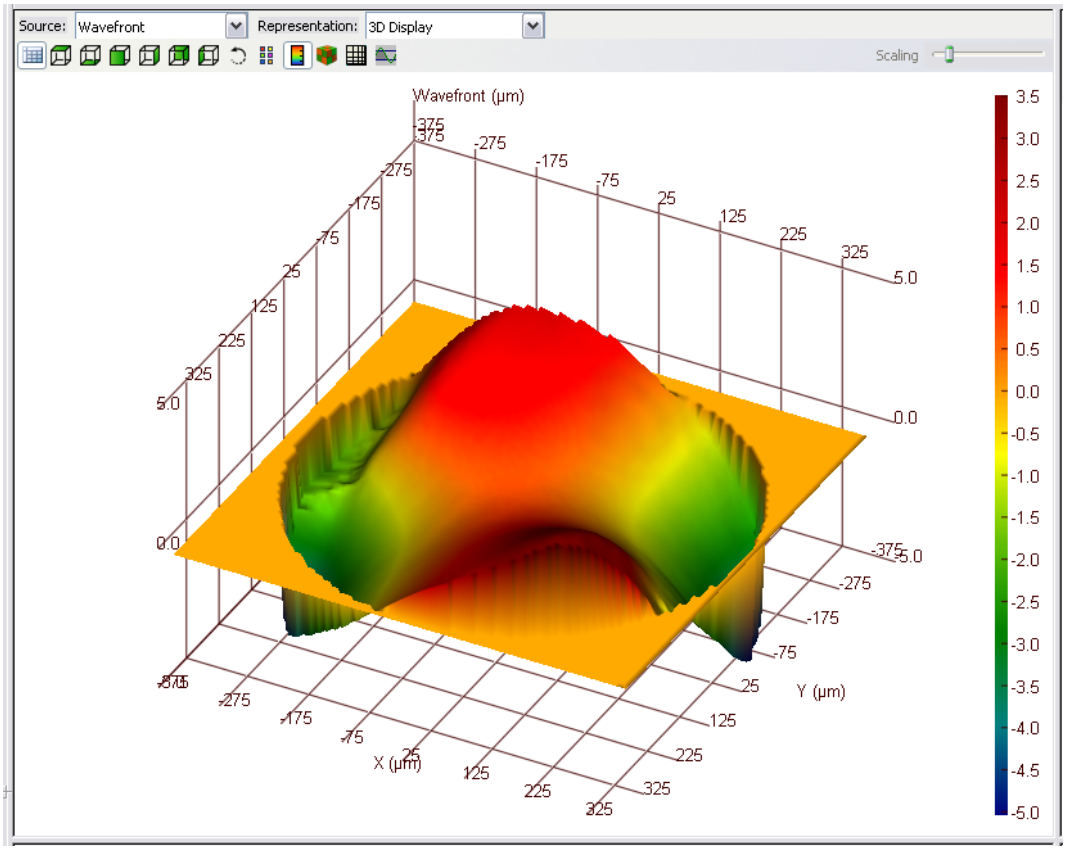

Figure 3.3. Wavefront view

The property view for wavefront data gives the beam radius value.

3.4. Zernike data

This view consists of a Zernike representation of the measured wavefront.

The Histogram representation shows a bar-graph of all calculated Zernike coefficients.

The Properties representation lists the values of the zernike coefficients.

You can adjust which coefficients to take into account for the Zernike representation in PROPERTIES > ZERNIKE. Checked coefficients will be taken into account for the Zernike representation.

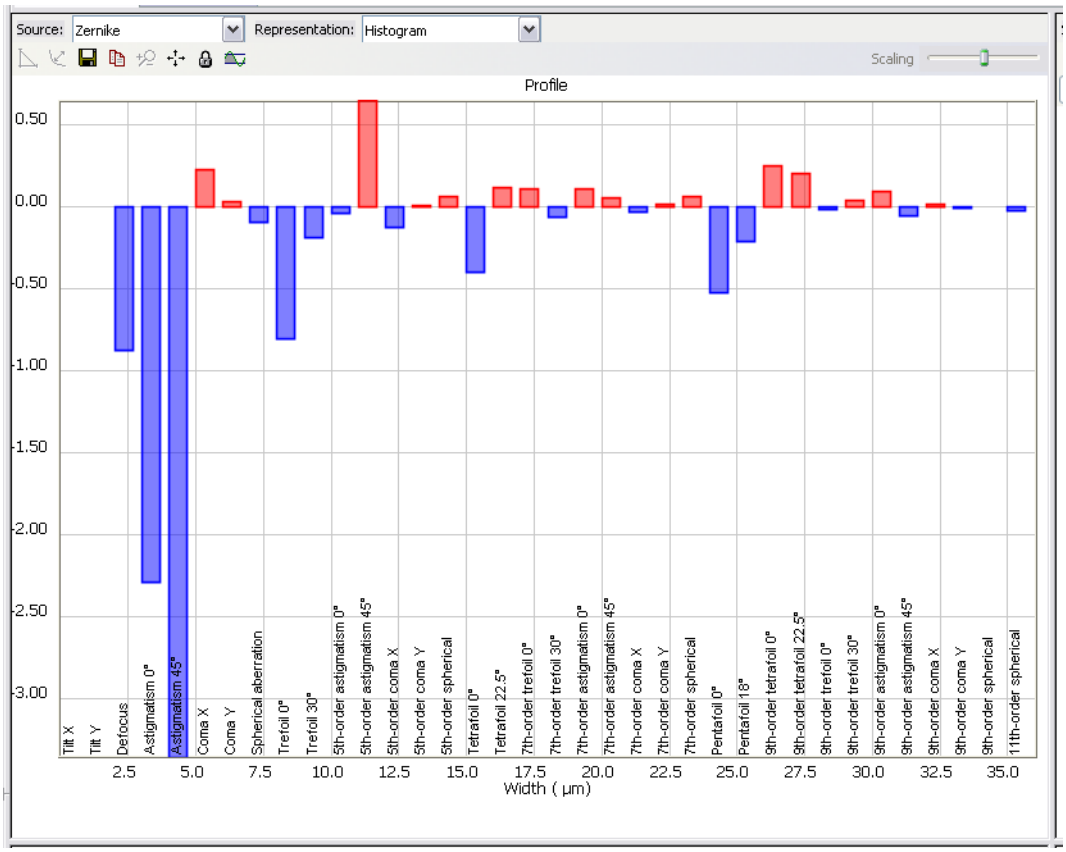

Figure 3.4. Zernike view

The description of Zernike parameters is given in the Zernike reference section

3.5. PSF data

This vue represents the point-spread function of the measured system. In other words, it is the image of a point object.

In order to calculate PSF, you must specify the system's focal length in PROPERTIES > PSF > FOCAL LENGTH. Note that changing the focal length will only change the lateral scale of the PSF.

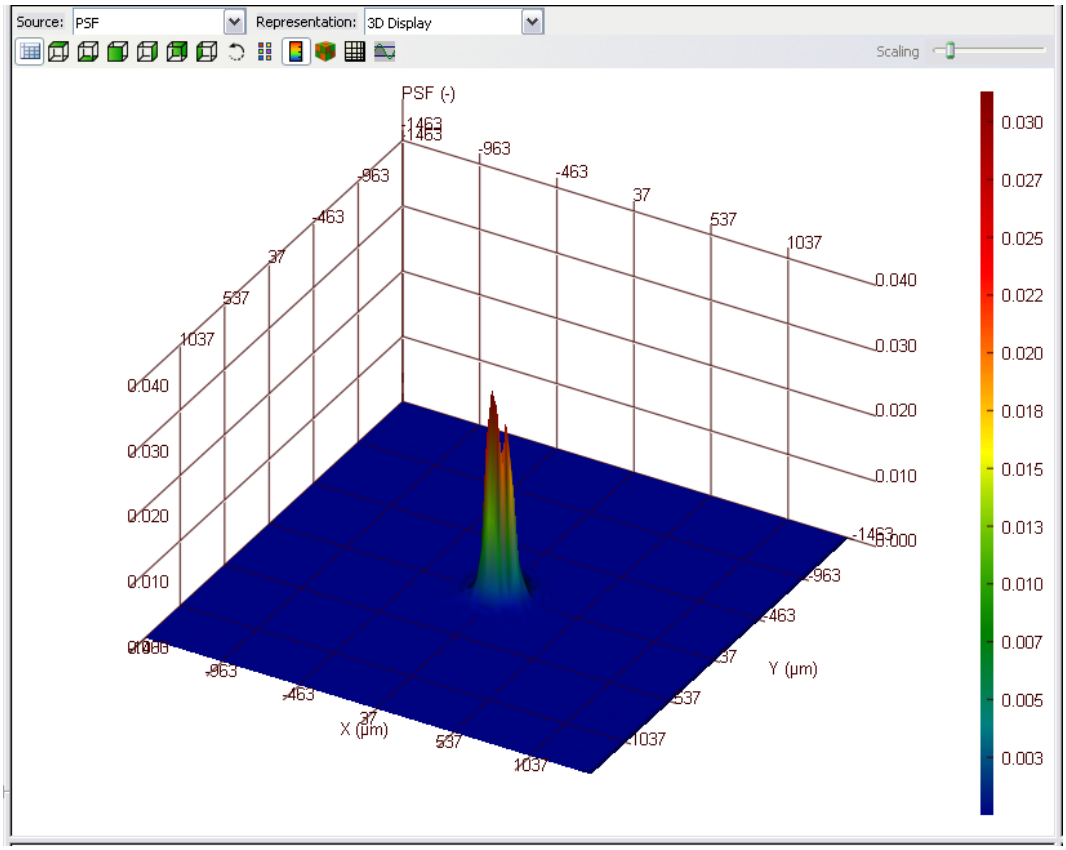

Figure 3.5. PSF view

The property view for PSF gives the Strehl ratio of the measured system. This is by definition the ratio of the peak intensity of the image of a point, compared to the peak intensity that would be obtained with a diffraction-limited system.

3.6. Propagation tool

The propagation tab allows you to predict the beam profile before and after the sensor.

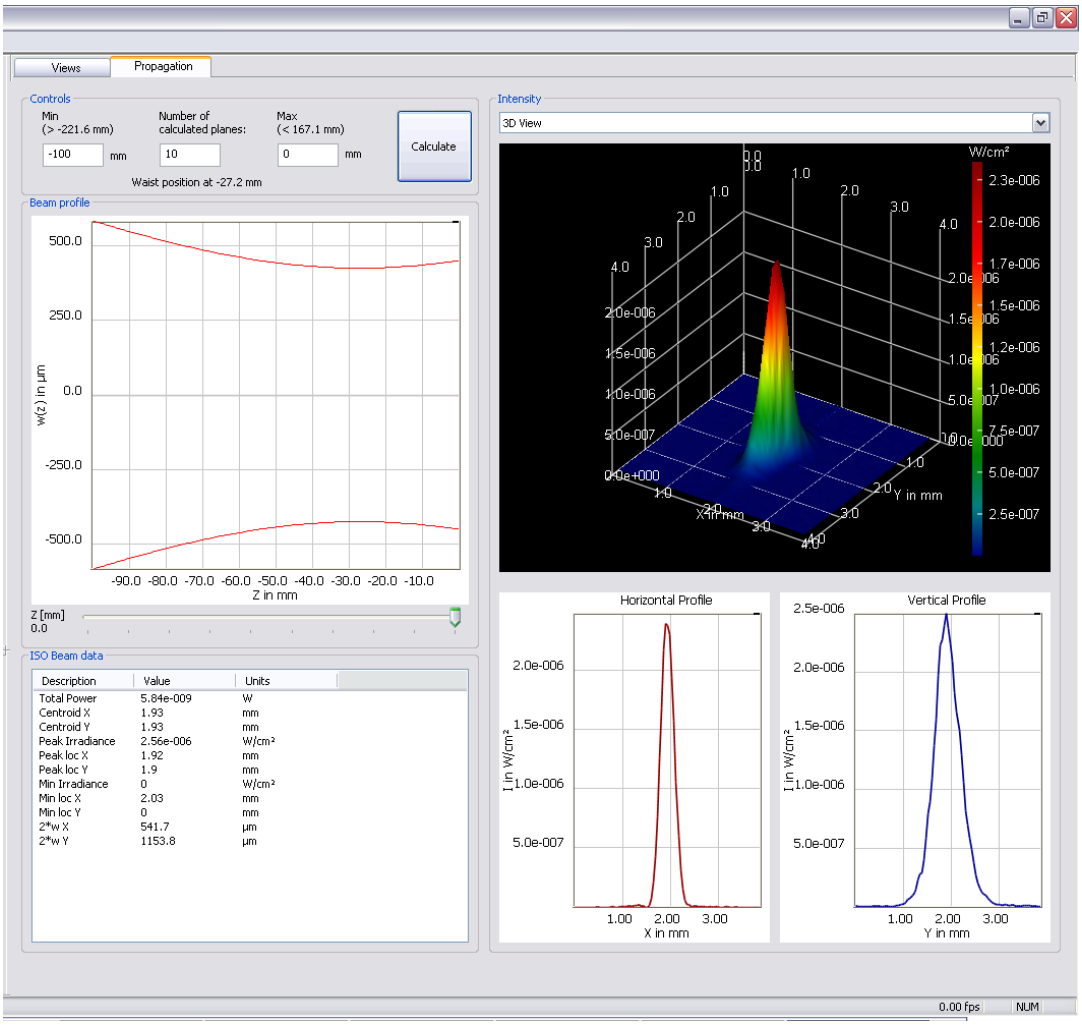

Figure 3.6. Propagation tab

To propagate a measured beam, proceed as follows:

1. Select the starting and ending position for propagation, within the propagation limitsMin and Max.
2. Select the number of images to calculate
3. Click CALCULATE
4. Move the cursor under the beam profile to select any of the calculated beam position. For each select position, you can review the intensity view, ISO beam data and intensity profiles

3.7. Report

A measurement report can be automatically generated by going to FILE > SAVE REPORT. The report will include the currently selected views.

Chapter 4. Tools

This chapter describes the functions available in the TOOLS menu.

4.1. Lens selector

This tool is useful for setting-up a laser beam measurement with optimum parameters.

In order to obtain the highest accuracy for laser beam parameters measurements, it is recommended to fulfill the following conditions:

- The beam waist diameter should be between 90 µm and 400 µm.
- The sensor should be located at a distance between 0.5 and 2 Rayleigh range(s) before or after the waist location.

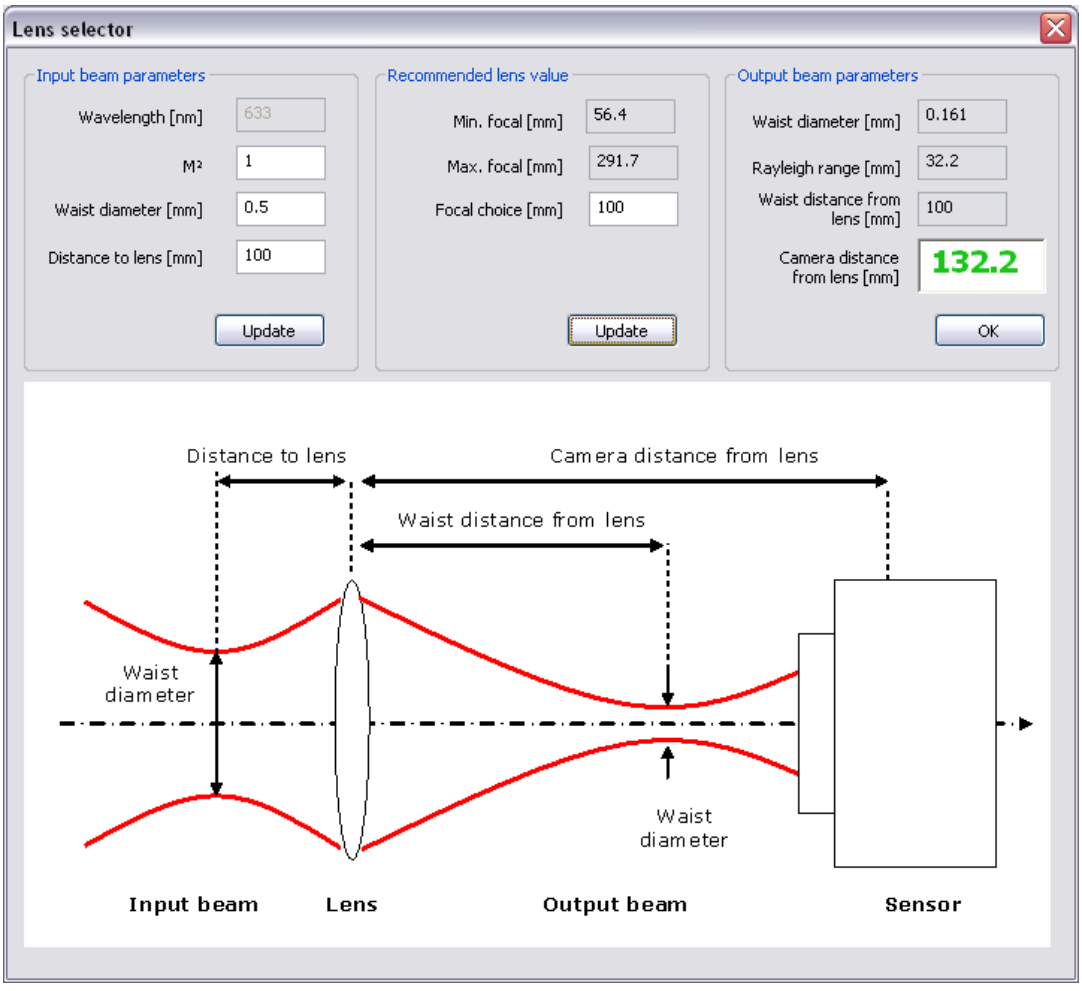

Figure 4.1. Lens Selector

If the initial beam waist is too small or too large, a lens can be inserted after the initial beam waist. This will create a secondary waist that meets the requirements above. The Lens Selector helps you choose the appropriate lens focal length and position:

1. Enter the estimated M² value of the beam.
2. Enter the estimated waist diameter of the input beam.

3. Enter the distance from the initial waist to the location where you wish to insert the lens. Click UPDATE.

4. The Lens Selector gives you a range of appropriate focal lengths for the additional lens. Choose a value within this range and enter it in FOCAL CHOICE edit box, then click UPDATE.

5. The Lens Selector will calculate the secondary waist properties, and give you the optimum position to place the sensor with respect to the additional lens.

4.2. Attenuator Selector

This tool is useful for selecting the proper attenuator for a given laser beam.

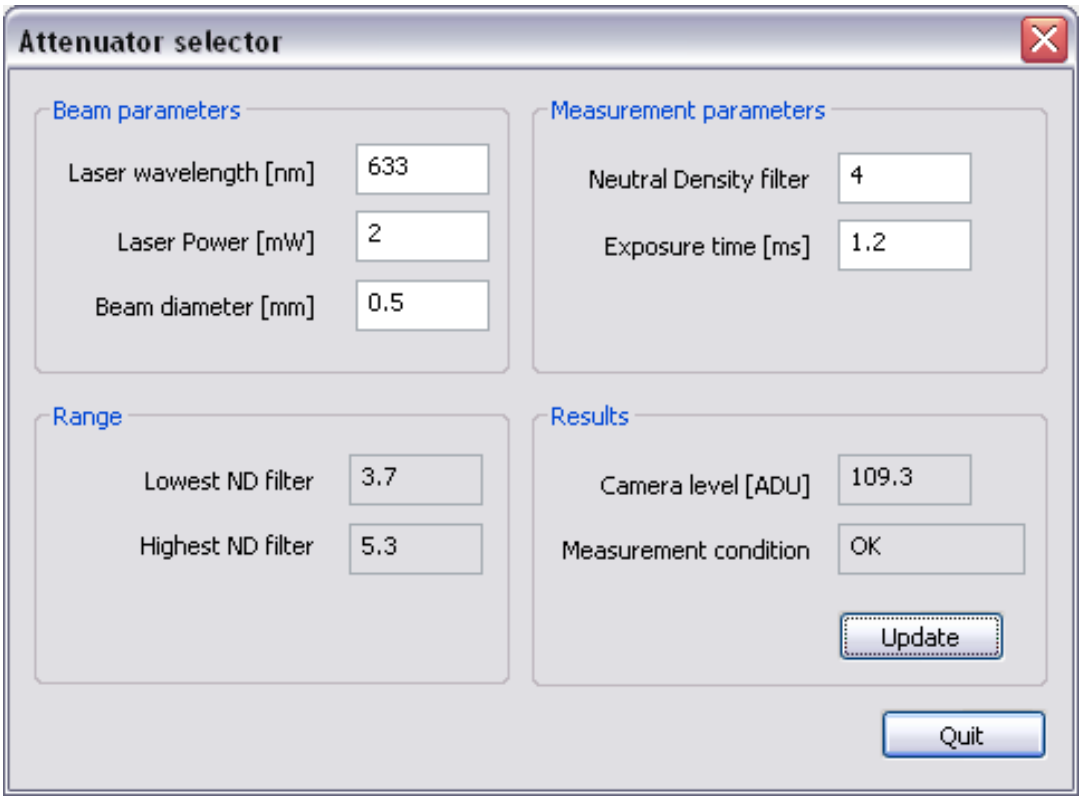

Figure 4.2. Attenuator Selector

Follow this procedure to determine the best attenuator:

1. Enter the beam wavelength.

2. Enter the average laser power in mW.

3. Enter the estimated beam diameter on the sensor

4. Click UPDATE. The Attenuator Selector will give you the range of possible attenuator.

5. (OPTIONAL) You can enter your choice of attenuator and exposure time and click UPDATE again to check if the corresponding measurement will be good, underexposed or saturated.

Warning

For pulsed laser beams, additional precautions must be taken to not exceed the sensor's damage threshold.

Chapter 5. Reference

5.1. Preference menu

This section describes the various preference settings, which can be modified via the PROPERTY menu at the bottom left of the screen.

Category	Item	Description
System	Wavelength	Enter light source central wavelength, in nanometers
	Offset X	This is a calibration parameter that compensates for sensor tilt along the X-direction. The best way to configure this parameter is to use the RESET TILT button.
	Offset Y	This is a calibration parameter that compensates for sensor tilt along the Y-direction. The best way to configure this parameter is to use the RESET TILT button.
	Objective magnification	Enter the objective magnification.
	Data resolution	This parameter determines the resolution of output data. Lowering the resolution increases the measurement speed.
Wavefront	Remove tilt X	Check this parameter to ignore measured tilt along X-direction.
	Remove tilt Y	Check this parameter to ignore measured tilt along Y-direction.
	Remove defocus	Check this parameter to ignore measured defocus.
	Remove reference	Check this parameter to remove a reference wavefront from each measurement.
	Reference path	Specify here which reference wavefront to subtract (pvf file).
Zernike	Zernike coefficients	Check all coefficients that you want to consider for the Zernike representation of the measured wavefront.
PSF	Focal length	Specify what focal length to use for the calculation of PSF and MTF.

Table 5.1. Preference settings

5.2. Zernike polynomials

The polar coordinate system is defined on the figure below:

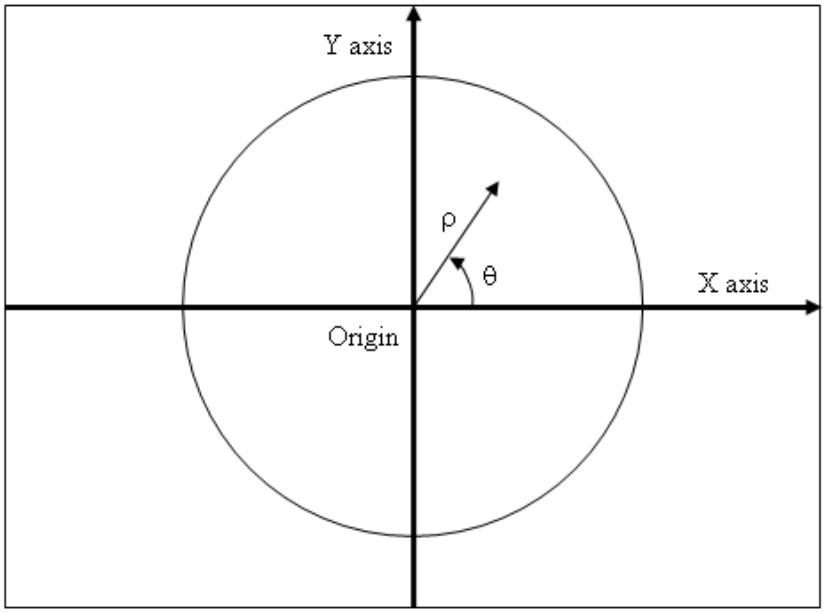

Figure 5.1. Polar coordinate system

We use the Zernike polynomials defined in the following table. The wavefront is decomposed on the basis of Zernike polynomials, which gives the Zernike coefficients, as follows:

$$W(\rho,\theta) = \sum_i c_i Z_i(\rho,\theta)$$

where:

W is the calculated wavefront, in meters
c_i are the Zernike coefficients
Z_i are the Zernike polynomials

#	Aberration name	Zi formula
1	Tilt X	$\rho \cos(\theta)$
2	Tilt Y	$\rho \sin(\theta)$
3	Defocus	$2\rho^2-1$
4	Astigmatism 0°	$\rho^2 \cos(2\theta)$
5	Astigmatism 45°	$\rho^2 \sin(2\theta)$
6	Coma X	$(3\rho^2-2)\ \rho \cos(\theta)$
7	Coma Y	$(3\rho^2-2)\ \rho \sin(\theta)$
8	3rd order spherical aberration	$6\rho^4 -6\rho^2 +1$
9	Trefoil 0°	$\rho^3 \cos(3\theta)$
10	Trefoil 30°	$\rho^3 \sin(3\theta)$
11	5th-order astigmatism 0°	$(4\rho^2-3)\ \rho^2 \cos(2\theta)$
12	5th-order astigmatism 45°	$(4\rho^2-3)\ \rho^2 \sin(2\theta)$

#	Aberration name	Zi formula
13	5th-order coma X	$(10\rho^4 -12\rho^2 +3)\ \rho\cos(\theta)$
14	5th-order coma Y	$(10\rho^4 -12\rho^2 +3)\ \rho\sin(\theta)$
15	5th-order spherical	$20\rho^6 -30\rho^4 +12\rho^2 -1$
16	Tetrafoil 0°	$\rho^4\cos(4\theta)$
17	Tetrafoil 22.5°	$\rho^4\sin(4\theta)$
18	7th-order trefoil 0°	$(5\rho^2 -4)\ \rho^3\cos(3\theta)$
19	7th-order trefoil 30°	$(5\rho^2 -4)\ \rho^3\sin(3\theta)$
20	7th-order astigmatism 0°	$(15\rho^4 -20\rho^2 +6)\ \rho^2\cos(2\theta)$
21	7th-order astigmatism 45°	$(15\rho^4 -20\rho^2 +6)\ \rho^2\sin(2\theta)$
22	7th-order coma X	$(35\rho^6 -60\rho^4 +30\rho^2 -4\ )\ \rho\cos(\theta)$
23	7th-order coma Y	$(35\rho^6 -60\rho^4 +30\rho^2 -4\ )\ \rho\sin(\theta)$
24	7th-order spherical aberration	$70\rho^8 -140\rho^6 +90\rho^4 -20\rho^2 +1$
25	Pentafoil 0°	$\rho^5\cos(5\theta)$
26	Pentafoil 18°	$\rho^5\sin(5\theta)$
27	9th-order tetrafoil 0°	$(6\rho^2 -5)\ \rho^4\cos(4\theta)$
28	9th-order tetrafoil 22.5°	$(6\rho^2 -5)\ \rho^4\sin(4\theta)$
29	9th-order trefoil 0°	$(21\rho^4 -30\rho^2 +10)\ \rho^3\cos(3\theta)$
30	9th-order trefoil 30°	$(21\rho^4 -30\rho^2 +10)\ \rho^3\sin(3\theta)$
31	9th-order astigmatism 0°	$(56\rho^6 -105\rho^4 +60\rho^2 -10)\ \rho^2\cos(2\theta)$
32	9th-order astigmatism 45°	$(56\rho^6 -105\rho^4 +60\rho^2 -10)\ \rho^2\sin(2\theta)$
33	9th-order coma X	$(126\rho^8 -280\rho^6 +210\rho^4 -60\rho^2 +5)\ \rho\cos(\theta)$
34	9th-order coma Y	$(126\rho^8 -280\rho^6 +210\rho^4 -60\rho^2 +5)\ \rho\sin(\theta)$
35	9th-order spherical aberration	$252\rho^{10} -630\rho^8 +560\rho^6 -210\rho^4 +30\rho^2 -1$
36	11th-order spherical aberration	$924\rho^{12} -2772\rho^{10} +3150\rho^8 -1680\rho^6 +420\rho^4 -42\rho^2 +1$

Table 5.2. Definition of Zernike polynomials

5.3. BeamWave mechanical dimensions

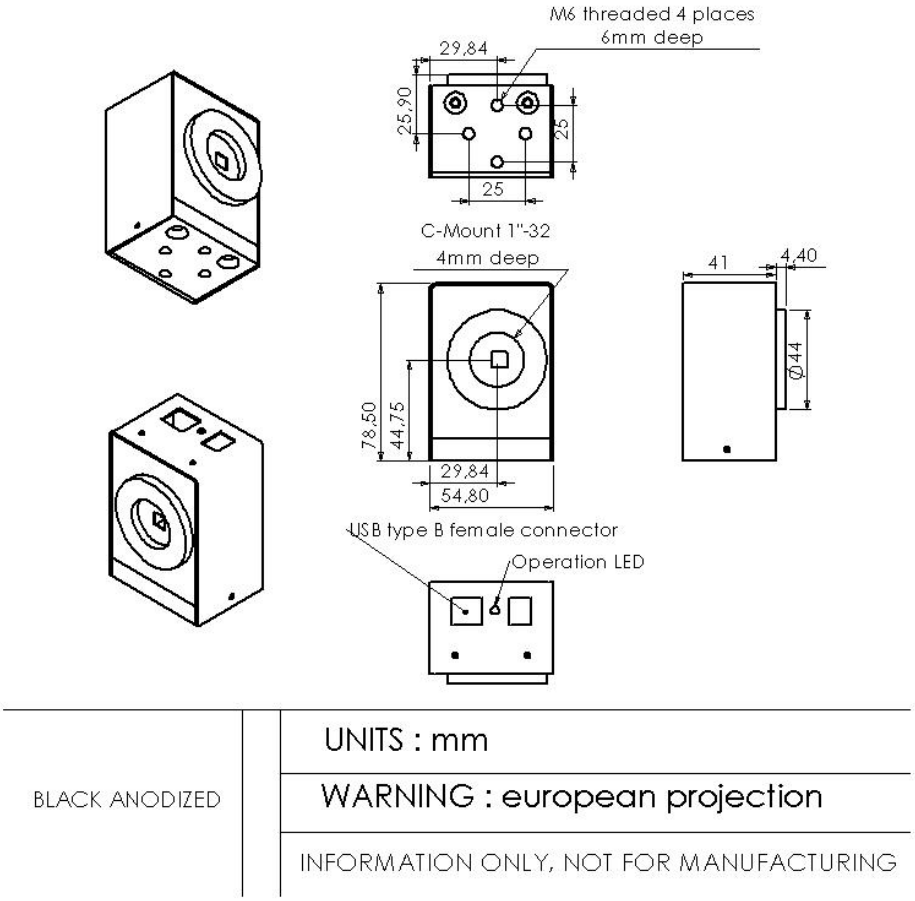

Figure 5.2. BeamWave mechanical dimensions

5.4. Troubleshooting

Refer to the list of error messages below for troubleshooting your application.

1. **Message.** Failed to connect

   Cause: software was unable to connect to the camera.

   Remedy: check that camera is properly connected:

   - USB cable should be connected to camera and computer
   - Camera LED should be ON.
   - If necessary, reinstall camera drivers.

2. **Message.** Initialization error. Missing reference pvf?

   Cause: some reference file is missing.

   Remedy: reinstall application

3. **Message.** Project is empty!

   Cause: saving failed because there was no data to save.

   Remedy: perform acquisition before saving.

4. **Message.** Can't read file

   Cause: project file cannot be read.

   Remedy: this data file is invalid. Try with another data file (pvf format).

5. **Message.** Wavefront calculation error

   Cause: Measurement failed because acquired image in invalid.

   Remedy: verify system alignment and exposure settings to make sure beam is centered and sufficiently bright.